

Nanofluids Can Take the Heat

Need

Traditional heat-transfer fluids used in vehicle thermal management systems (coolants and oils) exhibit inherently poor heat-transfer properties compared to most solids. In addition, conventional fluids that contain millimeter- or micrometer-sized particles are not suitable for rapid cooling in the miniature mechanical and electronic devices that are emerging, because the particles can clog the tiny channels of these microdevices. Therefore, fluids must be developed that can take the heat and flow in microchannels.

Argonne Solution

Nanoparticles possess unique properties that can be used to develop ultra-high thermal conductivity fluids. By exploiting these properties, Argonne researchers have pioneered an innovative new class of heat-transfer fluids — nanofluids — that are engineered by suspending nanoparticles (<40 nm) in conventional heat-transfer fluids. Nanofluids are capable of conducting heat much more rapidly than conventional fluids and flowing smoothly in microchannels.

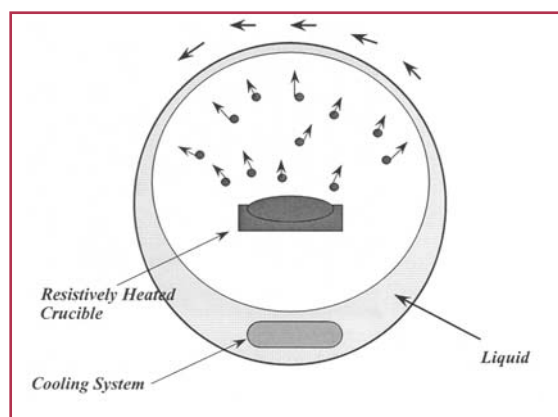


Figure 1. Schematic diagram of the single-step nanofluid production system, which simultaneously makes and disperses nanoparticles into low-vapor-pressure liquids.

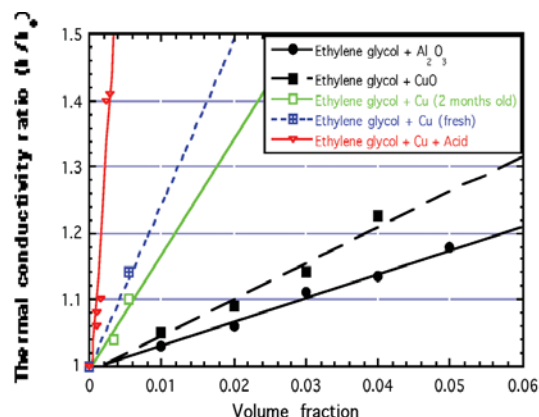


Figure 2. Metallic nanofluids provided by the single-step method show dramatic enhancements over the oxide nanofluids.

Approach

Argonne has developed two methods for producing nanofluids. These methods help ensure compatibility with a wider range of applications by allowing the most appropriate nanoparticle material to be chosen for a particular fluid.

- Single-step direct evaporation method simultaneously makes and disperses the nanoparticles directly into the base fluids — best for metallic nanofluids (see Figures 1 and 2).
- Two-step process ("Kool-Aid™" method) first makes nanoparticles, then disperses them into the base fluids — works well for oxide nanoparticles.

Accomplishments

Argonne has produced nanofluids containing nanoparticles of different materials, including oxides, metals, and nonmetals. Dispersion experiments have demonstrated stable suspensions of nanoparticles in conventional heat-transfer fluids (Figure 3).

Impacts

Nanofluids have the potential to become the world's most energy-efficient heat-transfer fluids, with wide-ranging economic and environmental benefits:

- A better ability to engineer thermal properties translates into greater energy efficiency, smaller/lighter systems, lower operating costs, and a cleaner environment.
- The large thermal conductivity improvement obtained with nanofluids holds significant potential for revolutionizing industries that depend on the performance of heat-transfer fluids.

— Nanofluids are already being implemented in fields as diverse as transportation, air conditioning, micromachines, networking, and energy supply.

— In medicine, scientists are currently examining ways to use nanofluids to save lives. Dispersing magnetic nanoparticles into the blood, guiding them magnetically to a cancerous tumor, and using a laser or magnetic field to transfer energy to the particles might destroy the tumor without significantly heating the blood or damaging nearby healthy tissue.



Figure 3. Oil prior to (left) and after (right) dispersion of copper nanoparticles. The nanoparticles dispersed in fluids can drastically change the appearance, as well as the conductivity, of the base fluids.

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